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SEASONAL VARIATION IN DISSOLVED OXYGEN AND ORGANIC POLLUTION INLDICATORS OF LAKE CHAD BASIN AREA OF BORNO STATE, NIGERIA

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ABSTRACT
Surface water and sediment samples from six (6) sampling stations of Lake Chad were monitored for seasonal variations in Dissolved Oxygen (DO) and some organic pollution indicators (BOD, COD and TOC). Sampling points were on the basis of human and aquatic activities around the lake. Determinations were conducted on-sites with Jenway portable meters for DO; while Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) were determined by standard methods, respectively. Results show variations in values with season with DO value ranging between (5.70$\pm$0.29 – 6.66$\pm$0.30) with Baga wet season having highest DO (6.66$\pm$0.30mg/l) and low BOD value of 3.20$\pm$0.21. The BOD was higher during the wet season than the dry season. In conclusion, the results of the pollution indicators obtained in this study area show that Lake Chad is less polluted and could support aquatic process. However, further monitoring is needed to evaluate the extent of pollution in terms of toxic heavy metals, pesticides, and biological activities.

KEYWORDS: Surface water, Aqueous sediment, Dissolved oxygen, Season pollution indicators, Lake Chad, Borno.

INTRODUCTION

Organic pollution indication study is an important way of ascertaining the level of pollution of a given river, lake or pond. The measurement of dissolved oxygen (DO), Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) could indicate the level of pollution of a given stream or river (Manahan, 2005). Lake Chad has a water surface area exposure, fluctuating in size between 25, 000 and 15,000 Km^2 and up to 2,000 Km^2 during severe drought. This corresponds to a water volume of 20 – 100 x 10^9 m^3. The average water depth is 2 m, with depth of as much as 7 m in the northern part of the basin and 11 – 12 m in the southern part (SATTEC, 1992). The highest water level of the Lake in recent times is 283 m above msl (Durand, 1995) while during the Sahel drought its level is as low as 277 m msl. The Lake's highest water level is attained between Nov. and Jan. within a year. Thereafter, evaporation exceeds river inflow and the Lake level gradually declines until July. The water level is completely dependent on the amount of inflow from the Chari and Lagoon Rivers, as the effect of evaporation can be considered as relatively constant. 90 – 95% of the Lake's inflow (41 x 10^9 m^3/year) is derived from these two rivers.

The Nigerian sector of the Chad basin falls within the Sahel belt of Africa characterized by low rainfall (~ 500 mm a^{-1}) and high evapotranspiration (> 2000 mm a^{-1}). Perennial water source is from groundwater, although rivers and streams supplement seasonally. This region has experienced climatic variability recorded in different natural archives, from the late Pleistocene to the present day. This has significantly affected the landforms and soils, surface and groundwater resources of the area. There is often a complex relationship between climate, geomorphology, vegetation and groundwater, where for instance reduced rainfall may create a desert landform with reduced vegetation, while infiltration rate may increase due to permeable unconsolidated sediments and low transpiration favoring increase recharge. The Lake Chad basin is located in the southwestern part and constitutes approximately 6.5% (152, 000 km^2) of the basin.(Edmunds,*et al*.1988) But in the short-term, reduced rainfall will lead to reduced recharge and lowering of the water table. The soils of the area in general are sandy especially in the uplands favoring high infiltration, while the depressions are clayey with low infiltration capacity. The unsaturated zone sediments are sandy and unconsolidated with high permeability, although low conductivity clayey sand and clay horizons have been encountered in some of the profiles, hampering movement of soil water. The storage and transport capacity of the study area can easily be visualized from the unsaturated zone moisture profiles; where high moisture in clays corresponds to high storage and low moisture content in sands relates to high transport capacity. What is apparent is

that the matrix conditions in the unsaturated zone, sometimes very subtle ones that are not immediately obvious from the samples taken, have a profound influence on detailed soil water movement.

The Chad Formation, the youngest stratigraphic sequence in the basin, which slopes gently east and northeast towards Lake Chad, underlies the Nigerian sector of the Chad basin. This Formation is overlain by superficial Lacustrine, Fluvial and Aeolian deposits, which break the featureless plain of the area. These superficial deposits create lacustrine clay flats locally known as "firki" at the eastern part and in the interdunal swells, fluvial sands and gravel along river channels, and active and stabilized sand dunes in the northern part.

The present climatic regime in this area is simple, consisting of a long dry season (October to May) and a shorter rainy season (June to September), which are related to seasonal winds. During the winter months the cool, dry, dust-laden "harmattam" blows from the Sahara in the north, bringing low humidity, cool nights and warm days. In the summer months, moisture-laden winds blows from the Gulf of Guinea in the south, bringing higher humidity, rains, and more uniform diurnal temperature. The monsoon advances from the south so that the rains start earlier, are heavier and last longer southwards, although in general there is high spatial and temporal variability over the entire area. The present day rainfall at the Maiduguri station for the 2001 season is 670 mm, very much similar to the long-term average and thus some 20% higher than the average for the Sahel drought period. Thus, the aim of this study is to assess the seasonal variations in some critical pollution indicators of the lake with a view to drawing a baseline data necessary for effective monitoring of the region.

MATERIALS AND METHODS

Sample and sampling

A total of 4 samples were collected monthly from each of the six different sampling points to constitute representative samples of a particular region. Pre-cleaned plastic containers were first rinsed with the water sample before final collection. For all the samples collected, the containers were dipped well below the surface of the water and allowed to over flow for sometime before they were covered and labeled appropriately.

Sample Preparation and Analysis

100cm^3 of the water sample were transferred into a beaker and 5cm^3 of aqua regia (HNO_3: HCI, in the ratio of 3:1) were added. The beaker with its content was placed on a hot plate and evaporated in a fume chamber. The beaker was cooled and another 5cm^3 of aqua regia were added again. This time, the beaker was covered with a watch glass and returned to the hot plate. The heating was continued and a small amount of aqua regia was added intermittently in order to complete the digestion. Another 5cm^3 of aqua regia were added, the beaker was warmed slightly so as to dissolve the residue (Skoog and West, 1975; Radojeric and Baskin, 1999). Procedure was performed for every water sample analysed.

DETERMINATION OF DISSOLVED OXYGEN (DO) IN WATER SAMPLE

200cm^3 of water sample was collected unto a beaker and a probe of the DO meter was inserted. The DO meter was switched ON and DO value (mg/l) was recorded after 2 minutes of automated value adjustment.

DETERMINATION OF BIOCHEMICAL OXYGEN DEMAND (BOD) IN WATER SAMPLE

Using a clean graduated cylinder, 420ml of water samples was measured and poured on to an amber colored sample bottles. The sample was cooled to about 20^{o}C and poured into a BOD track sample bottle. To each bottle 3.8 cm magnetic stir bar was dipped and one BOD nutrient Buffer pillow added for optimum bacteria growth. A stop cork was greased and applied to the lip of each seal cap and placed on the neck of each bottle. To each seal cup, one lithium hydrochloride powder was added by use of funnel and placed on the chassis of the BOD track. Tubes were then connected; caps tightened tagged, and finally placed in an incubator. The stir bars were made to rotate properly and appropriate test duration (5 days) programmed by pressing channel number corresponding to each bottle. After 5 days period, BOD results were read directly from the BOD track display by pressing the key corresponding to each sample. In above analysis, as a caution, the lithium hydrochloride particles were not allowed to fall into the sample, hence the use of funnel.

DETERMINATION OF CHEMICAL OXYGEN DEMAND (COD) IN WATER SAMPLE
20cm^3 of sample, 0.4g $HgSO_4$, and 2mg of sulphanilic acid, 10 cm^3 of standard $K_2Cr_2O_7$ solution and several dry glass beads were transferred into a reflux flask. With gentle swirling, 30cm^3 of Ag_2SO_4/H_2SO_4 solution were added. The content of the flask was thoroughly mixed and refluxed for two hours. The refluxed samples were cooled and diluted to 150cm^3 with distilled water. This volume was transferred to a conical flask and 2 drops of ferroin indicator were added and titrated against standard ferrous ammonium sulphate (FAS) solution until a color change from blue to reddish brown was observed. The volume of standard FAS used was recorded as V_s (cm^3). The same procedure was repeated for the rest of the sample. (Ademoroti, 1996).

DETERMINATION OF TOTAL ORGANIC CARBON (TOC) IN SEDIMENT SAMPLE
The different sediment samples were dried to a constant weight in an oven. The samples were ground to fine powder in mortar and sieved through a 0.24mm sieve. 0.3g of the sample was weighed into 500cm^3 conical flask. 10cm^3 of 0.5M K2 Cr_2 O_7 were added and the suspension was swirled gently. 20cm^3 of conc. H_2SO_4 added into the suspension. The mixture was swirled immediately and allowed to stand for 30 minutes. Then 200cm^3 of distilled water were added into the content of the flask followed by 10cm^3 of conc. H_3PO_4 cautiously. This was cooled and 3 drops of ferroin indicator solution were added. This reagent was titrated against standard (0.25M) FAS solution to wine-red colour end-point. The standard FAS titre values were recorded as V_s cm^3.

A blank determination using the above procedure was carried out but without the sample sediment. The FAS titre value for blank titration was recorded as $V_b$cm^3. The total organic carbon of the sediment sample (TOC) were obtained using the following expression, (Ademoroti, 1996)

$$\% \text{ Total organic carbon} = \frac{(V_b - V_s) \times M \times K}{\text{weight of sample(g)}}$$

Where,
V_b = cm^3 FAS used for blank
V_s = cm^3 FAS used for sample
M = Molarity of FAS
K = 1.38

RESULTS
Fig. 1 represents a plot of DO against temperature (°C) with concentration coefficient (r=0.61) Figs. 2, 3, 4, 5 and 6, respectively showed the plots of DO against BOD5; COD against BOD_5; BOD_5 against TOC; COD against TOC and DO against TDS. The lowest concentration coefficient was recorded in Fig. 3 with a value of r=0.70.

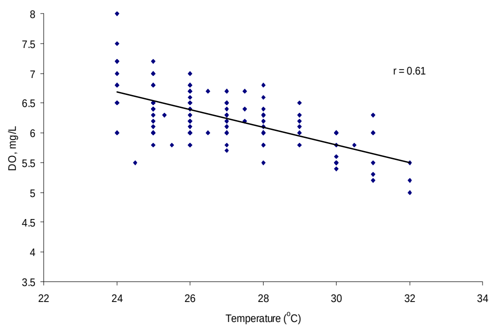

Fig. 1: Scatterplot of Dissolved Oxygen and Temperature Profile of Lake Chad Basin (2004)

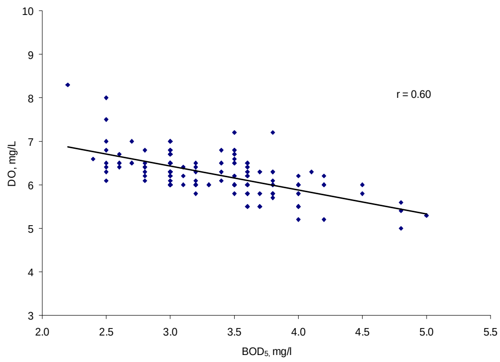

Fig. 2: Scatterplot of DO and BOD_5 of Lake Chad Basin (2004)

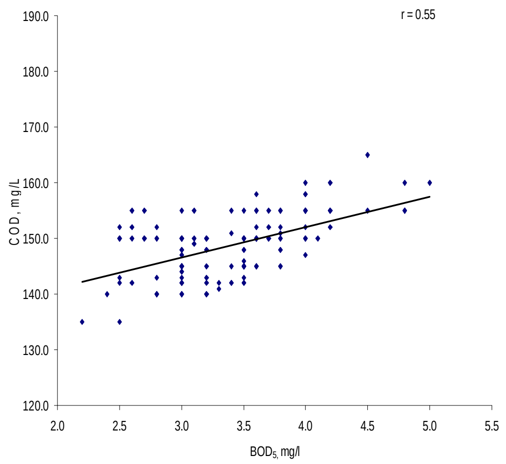

Fig. 3: Scatterplot of COD and BOD_5 of Lake Chad Basin (2004)

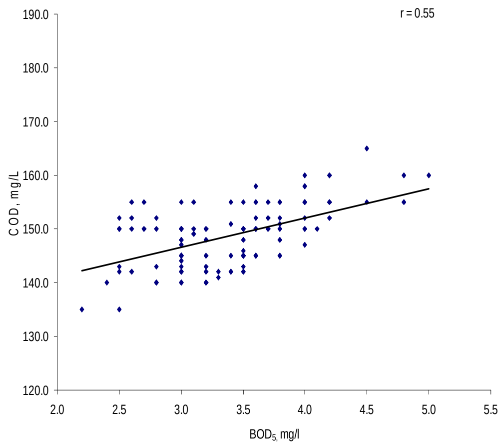

Fig. 3: Scatterplot of COD and BOD_5 of Lake Chad Basin (2004)

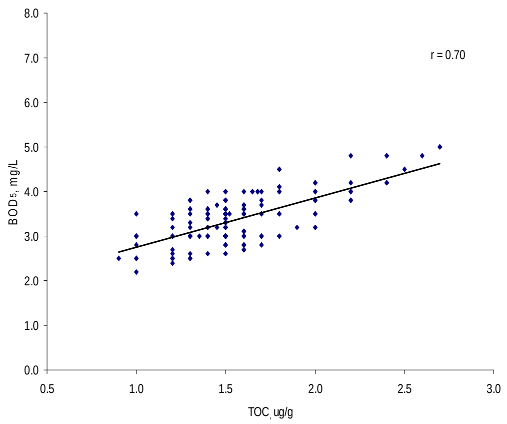

Fig. 4: Scatterplot of BOD_5 and TOC of Lake Chad Basin (2004)

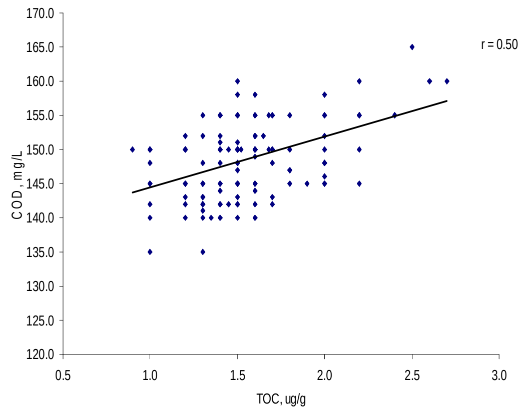

Fig. 5: Scatterplot of COD and TOC profile of Lake Chad Basin (2004)

DISCUSSION

The value of the pollutant indicators BOD, TOC, COD shows low level of pollutant with an applicable DO value necessary to support agricultural activities in the sample areas. Plot of DO against temperature in Figure 1 showed decrease in DO with increase in concentration during dry season showing higher values. This could be attributable to the heat absorbed from the sun. Also Figure 4 showed plot of BOD against TOC with linear concentration in both session suggesting the possibility of sorption of the organic materials in the segment which may reduce the available oxygen for biochemical process thereby making the water to lose its oxygen content suitable for supporting aquatic activities. Many causes of pollution results from the use of pesticides, agricultural crops and organic compounds affects the environment and humans (Hammer, 1997; O'neal, 1983).

Plot of COD against TOC also shows similar pattern in both season with wet season having highest TOC values. This is expected as during the rainy season because there is increase in water loads which will make the water turbid and increases its dissolved solid contents. This will reduce the rate of penetration of high and reduce the dissolved

oxygen in the water, which consequently pollutes the water for domestic and household use. Low DO concentration hinders lives of aquatic insects and other smaller animals, which feed on and may lead to depletion of fish in such region. DO is important in protecting the aesthetic qualities of water. Water bodies required simple DO to avoid onset of conditions that results in release of foul smelling, odor (Symonds, *et al* 1981).
In conclusion, From above, the level of pollution of the sample area is low and water is chemically suitable to support aquatic and agricultural activities.

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